



# **DARPA Grand Challenge 2005**

## **Emergency Stop System Preliminary Guidance**

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## **Emergency Stop Safety System**

### **Preliminary Guidance**

DARPA Grand Challenge teams that participate in the National Qualification Event (NQE) and the DARPA Grand Challenge Event (GCE) are required to use a DARPA-supplied emergency stop safety radio and tracking system (E-stop). The E-stop serves two essential purposes: basic remote stop/start command of the autonomous ground vehicle and communication to DARPA of position-tracking data as the vehicle runs the NQE and GCE routes.

Because the E-stop is loaned to the team by DARPA for use in the Grand Challenge, the system remains the property of the U.S. Government and must be returned when directed by DARPA. Team leaders are required to sign an agreement acknowledging responsibility for the E-stop and its use before the equipment will be issued.

On June 1, 2005, the leaders of the teams invited to the NQE will receive this agreement by email with other related information. Team leaders must sign and mail the document to the address provided. Following receipt of the agreement, DARPA will ship the E-stop to the address on the agreement form. Team leaders must inventory the system received against the packing list and acknowledge receipt via email within 7 business days.

#### **Technical Guidelines**

The E-stop is an upgraded version of the DARPA Grand Challenge 2004 unit manufactured by Omnitech Robotics International ([www.omnitech.com](http://www.omnitech.com)).

The overall system consists of a two way safety radio subsystem (Omnitech DGCSR) and the tracking subsystem (Omnitech DGCTS [TS]). The radio subsystem consists of a safety transmitter (TX) and a safety receiver (RX). Both the RX and TS are installed on the autonomous vehicle. The TX is used by the team for testing in advance of arrival at the NQE, but is relinquished to DARPA upon arrival.

Teams are responsible for correct installation and powering of the units and providing effective responses to the E-stop commands. Mechanical interface specifications for the units are available at [www.omnitech.com/safetyradio.htm](http://www.omnitech.com/safetyradio.htm). The RX unit requires 12V DC power (10V min and 15V max) and draws approximately 1A average current, which must be provided by the vehicle. The TS derives power from the RX through a 30-inch interconnect cable, which must be accommodated in the installation with due consideration given to connector clearance and box location and orientation. The units should be installed at a location that affords protection from water (including all forms of precipitation) to ensure safe and reliable operation. The installation configuration should also ensure that the front panel display of the RX is readily accessible and viewable to facilitate unit testing at the GCE.

The TS should be mounted on the vehicle for use during the NQE and GCE, but must not under any circumstances be cabled to the RX or powered up until teams are expressly instructed to do so by DARPA at the NQE. Teams that fail to adhere to this instruction may incur liability for tracking system charges.

When installed, the RX has a 34-inch spring-mounted RF antenna with mounting bracket that should be mounted on the vehicle to afford a clear view of the horizon. In addition, both the RX and TS have external GPS patch antennas which require proper view of satellites overhead. All cables should be routed so water will not flow down the cables and reach the enclosure. Power should not be applied to any units until all antennas are properly installed and connected.

Teams are responsible for devising an effective means of using the E-stop controls to produce an appropriate sequence of actions on the vehicle to ensure safe control in autonomous mode. The E-stop system is actuated through two switches on the TX, the RUN/PAUSE switch and the ENABLE/DISABLE switch by means of an RF link. The RUN/PAUSE control changes the electrical state of two separate electrical outputs on the RX. A relay-based contact closure interface is provided that is rated to carry 3A of current. A second output suitable for interfacing to digital electronics is also provided, capable of sourcing 100mA. The ENABLE/DISABLE on the TX controls a second pair of outputs on the RX with similar specifications.

When in ENABLE mode the vehicle should respond to the RUN and PAUSE commands. The DISABLE command response should invoke the DISABLE response irrespective of the RUN/PAUSE switch setting. The vehicle must respond to these E-stop states with a safe and effective series of actions. Verification of the E-stop integrated on the vehicle is an essential prerequisite before the team can run the NQE course.

When in ENABLE mode, the PAUSE response must cause the vehicle to be brought quickly and safely to a rolling stop. The wheels should then be locked to eliminate the possibility of rolling, even on a slope. When a RUN command is issued in this state, the vehicle should resume operation after a 5-second delay (see section 3.6.4.1 of the rules). Vehicles must be capable of responding to repeated PAUSE/RUN command sequences and should resume motion in response to a RUN command, even after sitting in PAUSE mode for multiple hours or starting on a slope or in rough terrain.

The DISABLE command is used to stop the vehicle as in PAUSE mode and shut down the vehicle. A vehicle that is in DISABLE mode should not restart in response to a RUN command. The DISABLE command should apply brakes (such as a spring-loaded emergency brake) to stop the vehicle promptly and hold the vehicle in position even if it is on a steep slope. It should also quickly disable the main propulsion unit and as many vehicle systems as necessary (e.g. fuel pump and electrical bus) to shut the vehicle down.

The DISABLE command serves an important secondary purpose as a fail-safe backup means of controlling a vehicle that has failed to stop in response to a PAUSE command. Teams should use a conservative design approach to provide assured operation of safety-critical functions such as braking.

## **Requirements and Responsibilities**

The team may use its own safety system for operations before arrival at the NQE, but only the DARPA-provided E-stop will be used once the vehicle arrives for the NQE.

Teams should notify DARPA immediately of any problems with the E-stop. Teams must inventory the components of the shipped systems immediately upon arrival. Damage during shipping, faulty operation, missing parts, or other problems should be reported immediately. The team's E-stop must be fully functional for the team to be eligible to participate in the Grand Challenge.

The E-stop contains sensitive electronic systems and should be handled with care. Teams should avoid excessive heat, shock, electrostatic discharge, or humidity that could damage or impair the units. Electrical limits should be observed. Teams should read and observe the technical guidelines supplied with the units. The E-stop should be protected from water, including precipitation, at all times, including during operation at the Grand Challenge. Systems should be protected from incidental mechanical damage during testing including physical contact during operation in heavy brush.

The E-stop enclosures must not be opened for any reason. DARPA will provide the teams a technical support desk telephone number and email address to answer questions. If the support desk cannot resolve a problem, the team will be instructed to return the unit for in-shop repair or replacement. Teams must not attempt to repair or modify the E-stop without explicit written authorization from the support desk.

Teams should integrate and thoroughly test the E-stop on their vehicle in advance of arrival at the NQE. Teams that are not ready upon arrival at the track will not be allowed to compete and thus may incur a competitive disadvantage as a result of lost track time. Limited technical support will be available at the NQE.

Teams must return the complete E-stop (including antennas, cables, and associated hardware) in their original shipping containers within 24 hours of termination of involvement in the DARPA Grand Challenge. Should termination take place before the NQE, teams will ship the systems to the address provided with the unit. Should termination occur at the NQE, at the end of the NQE, at the GCE, or at the termination of the GCE, teams will return the systems to DARPA-identified personnel. Team leaders that do not return a complete E-stop will be liable to the U.S. Government for the replacement cost of the missing parts.

Teams should monitor the DARPA Grand Challenge web site and manufacturer web site ([www.omnitech.com](http://www.omnitech.com)) for the latest information.

## **Contact**

Prior to June 1, 2005, questions should be addressed to the Grand Challenge mailbox ([grandchallenge@darpa.mil](mailto:grandchallenge@darpa.mil)). Additional detailed specifications and user manuals will be made available on the Omnitech website no later than June 1, 2005. After that date, direct technical support will be available from the manufacturer as described in the E-stop package.